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A Critique of Defined Contribution Plans Using a Simulation Approach

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Abstract**

During the 1980s there was a trend in many countries away from defined benefit plans toward defined contribution plans. This development means that the individual member bears the full investment risk in the preretirement period and the annuity rate risk at retirement, as no pension benefit (expressed as a percentage of salary) is provided.

This paper, through the use of a stochastic model for both inflation and a range of investment returns, analyses the distribution of retirement incomes that will be produced from a defined contribution plan. The impacts of changing entry and exit ages, different investment strategies, alternative career paths, and different economic assumptions also are assessed. The uncertainty of the resulting income benefits is highlighted, and the question is raised as to whether the individual member is aware of these results.

Key words: *funding, pensions, risk*

1 Introduction

The provision of retirement income for employees traditionally has been initiated by employers through a defined benefit scheme providing pension benefits. During the last decade, however, there has been a significant shift in many countries toward the provision of retirement benefits through defined contribution plans (or money purchase arrangements). The reasons for this trend vary between countries, but include:

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a) The desire by some employers to reduce their risk present within a defined benefit scheme.

b) Increasing legislation, which often has made defined benefit plans more complex and costly to administer.

c) The presence of surplus in many defined benefit plans and the related issues of overfunding, which may have been encouraged by conservative actuarial assumptions.

d) The high rates of return in the 1980s which made defined contribution plans more attractive to members.

e) The trend toward individual responsibility and the desire by many governments for employees to accept greater responsibility in providing their retirement benefits (for example, with reductions in social security benefits in many countries).

f) The increasing levels of vesting and preservation required by many governments often have been expressed in terms of members' accumulated contributions.

g) Changing taxation structures that permitted and encouraged defined contribution arrangements.

The extent of this trend varies between countries, but it is present in sufficient countries to suggest a significant and long-term direction.

For example, within the United States the number of defined benefit plans decreased 16.7 percent in the five years to 1988 while the number of defined contribution plans increased 36.5 percent (Turner and Beller, 1992). In the same period, the level of contributions to defined benefit private pension plans decreased 43.2 percent to $26.3 billion in 1988 while the level of contributions to defined contribution plans increased 79.7 percent to $64.9 billion in 1988. Turner and Beller (1992, p. 9) note "the gradual but steady replacement of defined benefit plans by defined contribution plans as the primary vehicle for providing pension benefits." In many, but not all, of these cases the defined contribution benefit represents a benefit in addition to a pension from a defined benefit scheme.

Within the United Kingdom, the trend toward defined contributions plans has not been as strong. The introduction of personal portable pensions in 1988 with the associated legislation, however, has meant that many individuals have been encouraged to contribute to a money purchase (or defined contribution) arrangement.

The recent Australian experience also reflects the move toward defined contribution plans. In 1987 a national industrial agreement was handed down that granted most workers an employer contribution equal to 3 percent of earnings. In July 1992 this approach was

extended so that all employees now receive a minimum employer contribution of either 3 percent or 5 percent of earnings (depending on the size of the company). This minimum employer contribution will increase to 9 percent of earnings by 2002. Although defined benefit plans are permitted and remain with many larger employers, the legislation expresses the minimum contributions in terms of current earnings which represents a defined contribution approach.

This trend toward an increased reliance on defined contribution funds to provide employees' retirement benefits needs to be assessed in terms of the ultimate benefit provided to the member. Actuaries are aware that within a defined benefit pension scheme, the employer bears the investment risk, the salary inflation risk, and the longevity risk (if an annuity is not purchased by the fund). Within a defined contribution plan (where the employer contribution is set as a fixed percentage of the employee's earnings and the final benefit represents the accumulation of these contributions), however, the employer bears none of these risks. Indeed, all risks have been passed to the employee. If employees increasingly are bearing these risks, it is essential that policy makers, individual members, and the pension industry fully understand these risks. With this objective in mind, this research analyses the defined contribution arrangements from the member's perspective.

The paper will consider the benefits that arise from a contribution rate (fixed as a percentage of salary) allowing for stochastic investment and inflation rates and changes in a number of parameters, including contrasting investment strategies, different entry and retirement ages, fractional and full-time employment patterns, and the impact of different annuity rates available at retirement. A fixed 12 percent contribution rate has been chosen, as it provides an adequate retirement pension, on average, for a person who is a member for about 40 years if there are no social security contributions and benefits. For countries with compulsory social security, a lower level of fixed contributions would be appropriate and the benefits can be reduced proportionately. In Australia, where there exists no universal social security benefits, the government has a long-term objective of a total contribution rate equal to 12 percent of earnings.

2 The Model

2.1 Accumulation of Contributions and the Benefits Arising

During an individual's preretirement years, it is assumed that contributions (expressed as a percentage of annual earnings) will be

paid mid-way through each year and that investment income will be generated until retirement age. Allowance also can made for any tax payments on contributions and investment income. In many countries (for example, the United States, Canada, and most European countries) contributions and investment income are tax exempt, so the relevant tax variables (TAX_c and TAX_I) can be set to zero without affecting the model. A country where these rates are not zero is Australia where both employer contributions and investment income are taxed at a rate of 15 percent, although the investment tax rate normally is reduced to a net rate between 5 percent and 10 percent due to the availability of various credits.

Equation (1) represents the accumulated contributions available at retirement age for the provision of retirement income. Let AC_R be an employee's accumulated contributions after R years in the plan; then:

$$AC_R = K\ (1\text{-}TAX_c) \sum_{t=0}^{R-1} F_t\ SAL_t\ (1 + INV_t\ [1 - TAX_I])^{1/2} \times \prod_{u=t+1}^{R-1} (1+INV_u\ [1\text{-}TAX_I]) \tag{1}$$

where:

K	=	Rate of contributions as a percentage of earnings;
TAX_c	=	Rate of tax on the contributions, paid at the time of payment;
TAX_I	=	Net rate of tax on investment earnings;
F_t	=	Fraction of full time employment in year t (to allow for part timers);
SAL_t	=	Annual salary in year t;
INV_t	=	Gross rate of investment return earned in year t;
R	=	Number of years in the plan before retirement.

For the purposes of this paper, it will be assumed that this accumulated amount will purchase an indexed annuity (or pension) payable for life from the age of retirement. The value of the pension purchased can be expressed as follows:

$$AC_R = PEN\% \times SAL_{R\text{-}1} \times a(x) \tag{2}$$

where:

$PEN\%$ = Pension received as a percent of the individual's final salary;
SAL_{R-1} = Salary received in the final year prior to retirement;
$a(x)$ = Inflation-linked lifetime annuity factor for the retiree age x (i.e., at retirement).

Equations (1) and (2) must equal each other, as the accumulated amount at retirement provides the funds required to purchase a pension at a rate related to the person's age and sex. In any individual case, however, there are two parameters: namely K (the rate of contribution) and $PEN\%$ (the pension received in terms of final salary). Within a defined contribution fund, K is defined and the pension can be calculated based on the accumulated funds at retirement. In contrast, within a defined benefit pension fund, the pension percentage is defined (normally ignoring any tax on the pension) so that a recommended rate of K can be calculated using actuarial principles.

The above equations do not make any allowances for taxes on benefits (which vary by country, individual income, and benefit form) or expenses which may be in respect of initial expenses, regular administration or investment costs, or the costs associated with the purchase of an annuity. The important impact of expenses and the varied form in which they are paid will be considered in a subsequent study.

The provision of retirement income from savings in the preretirement years requires funds to be accumulated over many years; several long-term assumptions are therefore necessary. One approach is to use a deterministic approach and set pre-determined levels of inflation and investment return for each year. Such an approach, however, does not allow analysis of the risk facing the individual member. To provide greater reality in this model, simple stochastic models for inflation and the investment return will be used.

2.2 Inflation and Salary Assumptions

The stochastic model used for inflation allows for a one year lag as expressed in equation (3).

$$INFL_t = k \times INFL_{t-1} + (1-k) \times (\mu + \sigma Z_t) \qquad (3)$$

where:

Z_t = Standard normal variable for year t, i.e., $Z \sim N(0,1)$;
$INFL_t$ = Rate of inflation in year t;
k = A number between 0 and 1;
μ = Mean of the normal distribution representing inflation;
σ = Standard deviation of the normal distribution representing inflation.

The appropriate levels for k, μ, and σ^2 can be debated. After some empirical investigation into the inflation levels over the last 40 years in Australia, the following values provided a distribution of inflation values that is similar to the previous 40 years' experience:

k = 0.5 (that is, 50 percent of last year's inflation is carried into this year);
μ = 0.07;
σ = 0.07 (that is, the standard deviation).

The period of 40 years was chosen to cover the post-World War period. In addition, beyond 40 years there is a problem with the availability of reliable and consistent data.

Statistical tests show a significant effect for a one year lag, but no significance for a longer lagged effect. The value of k also was tested for all values between zero and one—a value of 0.5 provides a slightly better result than other values in the range of 0.25 to 0.75 and much better results than values outside this range.

Before proceeding, it is worth noting that the history of inflation does not necessarily indicate future levels. In particular, most OECD (Organization of Economic Co-operation and Development) nations have moved into a lower inflation environment. With this in mind, the results will concentrate on $\mu = 0.04$ and $\sigma = 0.04$. The effects of higher inflation rates, however, will be considered also.

As indicated above, the model requires an assumption in respect to a person's salary in each of his or her preretirement years (that is, the pattern of the person's salary from entry into the work force until retirement age). This paper's approach is to consider that the annual change in a person's salary comprises the following three components:

a) An increase related to inflation levels, which can be estimated from the inflation equation outlined above.
b) An increase as a result of general productivity improvements within the economy, which may be expressed as a percentage rate per annum.

c) A promotional increase that also will be expressed as a percentage rate per annum.

2.3 Investment Returns

The assumption of a single investment rate of return for a period of 20, 30, or 40 years to estimate the accumulated value of a person's retirement benefit is a bold and heroic assumption and is almost certain to be wrong! To provide greater understanding of the range of possible results, each simulation assumes that each year's rate of investment return is selected randomly from a distribution that represents the assumed experience, thereby allowing investment returns to vary on a year to year basis.

It is assumed that the investment return is achieved by a fund invested in a range of marketable assets with no promise of a guaranteed return. For the purposes of this study, it is assumed that the fund will invest in portfolios of bonds (both domestic and overseas), equities (both domestic and overseas), direct property, and short-term investments. That is, the fund will have a balanced investment strategy spread over several sectors. Naturally, the actual proportions in each sector will vary with the investment strategy adopted.

It also will be assumed that the real rate of investment return in year t is independent from the rate of inflation in that year. Although this result may appear surprising, a diversified portfolio with several sectors represented is more likely to achieve this independence than a portfolio concentrated in one asset form. For instance, if inflation rises, the prices of domestic bonds will decrease and equities and property may fall in value. Short-term and overseas investments may increase in value. Carter (1991), in the development of an Australian stochastic investment model, suggests that inflation affects short-term rates positively but dividend yields and property returns negatively and that share prices best are forecast as a separate white noise process independent from inflation.

Hence, in view of the assumed diversified nature of the investment portfolio and the lack of a clear relationship between the returns on equities and inflation, a real rate of return independent from the rate of inflation is considered reasonable. It is acknowledged that this investment model is a simplified one, but it is sufficiently realistic to enable this paper to concentrate on the benefits arising from defined contribution funds and thereby to draw appropriate conclusions. Models that concentrate on interest rates (for example, Becker (1991) and Tilley (1992)) have not been used due to the assumed diversified portfolio of the fund.

It also is recognized that pension and superannuation funds may adopt a range of investment strategies. With this in mind, the results allow for the following three investment strategies, each of which is represented by a normal distribution.

a) Strategy A: N (μ = 0.05 and σ = 0.08).
b) Strategy B: N (μ = 0.03 and σ = 0.05).
c) Strategy C: N (μ = 0.01 and σ = 0.02).

It should be noted that these three investment strategies represent, in broad terms, the following three investment options:

a) Strategy A represents a managed or balanced fund with significant investments in equities and properties.
b) Strategy B represents a capital stable fund with significant fixed interest investments and some equity investments.
c) Strategy C represents a fund invested predominantly in cash and short-term stocks.

The appropriateness of the assumed figures is confirmed by Humphreys and Newman (1993) who allow for an investment mix of cash, bonds (Australian and overseas), equities (Australian and overseas), property, and currency each with its own sector statistics and show a mean return (in excess of inflation) of 5.1 percent per annum with a standard deviation of 8.2 percent for a fund with a balanced asset mix and a mean of 3.9 percent per annum real and a standard deviation of 4.8 percent for a fund with a stable asset mix. Further, the *Towers Perrin Superannuation Pooled Funds Survey* (1993) of Australian fund managers shows for the three years to June 30, 1993 standard deviations of 5.8 percent, 7.6 percent, and 8.9 percent per annum for the benchmarks for funds that have below average, average or above average volatility for their investment returns.

Within the model, the rate of return each year is calculated so that 1 plus the nominal rate of return in year t is the product of 1 plus the inflation rate for year t and 1 plus the real rate of return for year t, for the given investment strategy. It is possible for the nominal rate of return in a particular year to be negative due to a negative real rate of return for that year.

As will be shown later, this model also permits individuals to change their investment strategies during their preretirement years, which is similar to the concept of age phasing discussed in Kingston, Piggot, and Bateman (1992). This possibility raises the question as to

who directs the investment policy: the employer, the member, or the trustees of the fund. A discussion of the advantages of each alternative is beyond the scope of this paper but is worthy of further research.

3 Results

As indicated above, the model can assume a defined contribution or a defined benefit approach. This paper initially will consider the retirement income benefits that arise for a single male in his retirement from a defined contribution of 12 percent of salary throughout his career. It is assumed that the full accumulated benefit at retirement is converted into an inflation-linked lifetime annuity.

Table 1 presents the results based on the following assumptions, except where an alternative assumption is noted.

Basic Assumptions

Entry age:	20
Exit age:	65
Participation:	full time throughout
Inflation rate–mean:	4 percent per annum
Inflation rate–standard deviation	4 percent per annum
Investment strategy A–mean	5 percent per annum real
Investment strategy A–standard deviation	8 percent per annum
Investment rate after retirement	1 percent per annum real
Salary growth–productivity	1 percent per annum
Salary growth–promotion	1 percent per annum
Mortality after retirement	Australian Life Tables 1985-1987

The investment rate of return after retirement has been assumed to be 5 percent per annum (i.e., 1 percent in excess of the mean long-term inflation rate), as it is assumed that the institution offering the indexed lifetime annuity will adopt a more conservative investment strategy than in the preretirement period.

Table 1 indicates the spread of results that arise from 1,000 simulations undertaken for each set of assumptions by showing the mean, standard deviation, the 5th percentile, and the 95th percentile for the 1,000 results produced under each scenario. One thousand simulations is sufficient to produce a stable set of results.

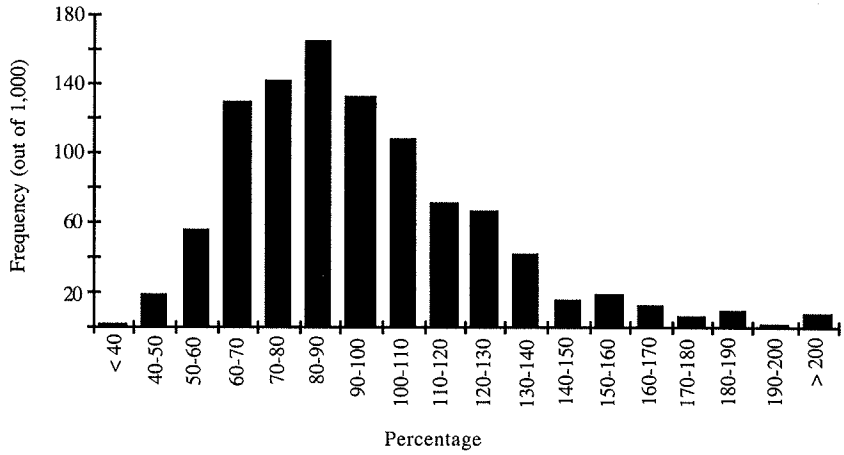
TABLE 1
The Indexed Retirement Income That can be Purchased With a 12 Percent Contribution Rate

Assumption	Retirement Income Expressed as a Percentage of Final Salary: Mean	Standard Deviation	5th Percentile	95th Percentile
Base assumptions	84.66	30.28	46.17	142.71
Female	67.81	24.42	36.82	114.15
Married male with spouse (2/3rds reversionary pension)	62.12	22.44	33.74	104.60
Changes in entry or exit ages				
Retirement age 60	56.98	19.12	31.78	93.11
Retirement age 55	38.22	11.90	22.11	61.12
Ages of 25 and 60	45.52	14.05	27.16	71.76
Retirement age 60 (female)	46.52	15.74	25.56	76.17
Retirement age 55 (female)	31.91	10.03	18.43	51.37
Ages of 25 and 60 (female)	37.17	11.58	21.97	58.51
Changes in investment assumption or strategy				
Strategy A with $\sigma = 6\%$	84.69	22.78	54.09	126.84
Strategy B	52.74	11.17	36.93	73.01
Strategy C	34.53	3.64	29.10	41.25
A for 35 years, then B	71.12	21.57	43.38	111.15
A for 35 years, then C	59.64	15.91	38.33	88.34
A for 25 years, then B for 10 years, then C	51.81	11.10	36.29	71.44
Changes in participation rates (part time is considered 40% of full time)				
f/t to age 30, then p/t to age 40, then f/t	71.58	24.89	39.72	117.71
f/t to age 25, then zero to age 35, then p/t to age 45, then f/t	48.24	14.89	28.69	75.12
f/t to age 30, then p/t to age 40, then f/t (female)	57.33	20.08	31.90	94.14
f/t to age 25, then zero to age 35, p/t to age 45, then f/t (female)	38.63	12.03	22.92	60.69
Changes in inflation and annuity assumptions				
Inflation N(4%,6%)	84.81	31.46	45.63	143.62
Inflation N(7%,7%) with annuity at 8% per annum	85.35	31.31	45.72	143.80
Annuity at inflation +0%	77.80	27.69	42.13	130.36
Annuity at inflation +1%	83.38	29.64	45.20	139.80
Annuity at inflation +2%	89.16	31.65	48.36	149.58
Career average—indexed	119.75	42.90	64.92	199.00

The most important result shown in Table 1 is the significant spread of the level of retirement income received by individuals who have contributed the same percentage of salary for the same number of years. For instance, using the base assumptions the average retirement income arising from a contribution of 12 percent of salary for 45 years is an indexed lifetime annuity equivalent to 84.66 percent of the person's final salary. Due to the uncertain investment returns

achieved each year, however, there exists a considerable spread of results. The level of retirement income is equally likely to be 46 percent or 143 percent of final salary, and these are not the extreme values! Figure 1 shows the distribution of these results.

Figure 1
Retirement Income as a Percentage of Final Income



The model also allows for taxation on contributions and/or investment earnings. Table 2 shows the results assuming a 15 percent tax on contributions (which is the tax rate payable in Australia on employer contributions) and a 7.5 percent tax on investment income. This represents a typical investment income tax rate paid by funds in Australia after allowing for dividend imputation and other credits. The tax on the resulting benefits also is reduced, but this is not shown as these tax rates vary by income and benefit size.

The major message coming from the results in Tables 1 and 2 and Figure 1 is that a considerable variation occurs in the ultimate level of retirement income received by individuals, even if a level contribution rate is assumed to be paid for 40 or 45 years. In essence, a system that defines a set level of contributions cannot define the level of benefits received. With the trend toward defined contribution plans, it is critical that fund members, employers, and policy makers appreciate that the prescribed level of contributions will not provide sufficient retirement income for many retirees, even if, on average, it is satisfactory under certain circumstances. It is worth stressing that

TABLE 2
Indexed Retirement Income That can be Purchased With a 12 Percent Contribution Rate After Allowing for a 15 Percent Contributions Tax and a 7.5 Percent Investment Tax

Assumption	Retirement Income Expressed as a Percentage of Final Salary: Mean	Standard Deviation	5th Percentile	95th Percentile
Base assumptions	61.10	19.83	35.08	98.12
Female	48.94	16.02	28.10	79.28
Married male with spouse	44.84	14.73	25.69	72.77
Changes in entry or exit ages				
Retirement age 60	41.97	12.87	24.44	66.44
Retirement age 55	28.74	8.24	17.61	44.80
Ages of 25 and 60	34.24	9.70	21.54	52.05
Retirement age 60 (female)	34.27	10.61	19.76	54.27
Retirement age 55 (female)	24.00	6.96	14.66	37.42
Ages of 25 and 60 (female)	27.96	8.01	17.36	42.49
Changes in Investment assumptions or strategy				
Strategy A with $\sigma = 6\%$	61.12	15.04	40.39	89.17
Strategy B	39.95	7.81	28.73	54.36
Strategy C	27.29	2.73	23.08	32.19
A for 35 years, then B	52.05	14.28	33.34	78.54
A for 35 years, then C	44.28	10.65	29.90	64.27
A for 25 years, then B for 10 years, then C	39.01	7.55	28.56	52.39
Changes in participation rates (part time is considered 40% of full time)				
f/t to age 30, then p/t to age 40, then f/t	51.87	16.29	30.32	81.08
f/t to age 25, then zero to age 35, then p/t to age 45, then f/t	35.68	9.89	22.40	53.92
f/t to age 30, then p/t to age 40, then f/t (female)	41.55	13.16	24.25	65.67
f/t to age 25, then zero to age 35, p/t to age 45, then f/t (female)	28.58	8.01	17.83	43.73
Changes in inflation and annuity assumptions				
Inflation N(4%,6%)	61.29	20.84	34.56	99.87
Inflation N(7%,7%) with annuity at 8% per annum	58.89	19.79	33.46	97.11
Annuity at inflation +0%	56.15	18.13	32.18	90.13
Annuity at inflation +1%	60.18	19.40	34.53	96.58
Annuity at inflation +2%	64.35	20.72	33.96	103.09

this inadequacy most likely will occur for a particular generation or cohort of retirees and not for retirees from a particular plan. For example, if the economy is depressed for a number of years (causing reduced investment returns), then all members of defined contributions plans will be affected. The effects could be particularly adverse for those approaching retirement who may find that the real value of their accumulated retirement benefits is declining. Such a result could

lead to a cohort of retirees with lower living standards for their retirement.

This result is not surprising when one recalls that within the operation of a defined contribution plan the rate credited to the member's account each year normally is linked to the fund's actual investment performance. Although funds in some countries may choose to smooth this rate, there is no doubt that the final benefit received by the individual largely is determined by the investment performance of the fund during the individual's working career. The investment risk that is borne by members of defined contribution plans translates into a risk that affects postretirement living standards. This is in contrast to a defined benefit fund where the retirement benefit is defined in terms of final (or final average) salary and the employer's contribution rate normally is adjusted to reflect changes in the investment return.

One method to reduce the variability in the level of retirement income received by the individual is the adoption of an investment strategy with less volatility, as assumed for Strategies B or C. While such an approach reduces the variability in the ultimate level of income, as shown in Table 1, a reduction in the level of retirement income also occurs. It is worth noting that, based on the model used, the 95th percentile for the low risk Strategy C represents a lower income than the 5th percentile for the higher risk Strategy A option. Similar results would be expected if other investment models were used.

A commonly suggested alternative is for individuals to reduce their level of investment risk as they approach retirement. Tables 1 and 2 show that while such a move reduces the variability in the level of retirement income received, it also reduces the expected income to be received. The expected income for the strategy involving the three investment options is below the 5th percentile for Strategy A. This result does not mean that a policy to reduce the volatility of investment return is inappropriate as individuals approach retirement. It does mean that the likely impact of such a move on the resulting income must be recognized.

The results also highlight the importance of realistic assumptions in any modeling, including variations in the rate of return. It is interesting to note that if the variations in inflation and investment returns are removed, the level of retirement income is 84.97 percent of final earnings (close to the mean). Such a single figure provides no indication of the variability in the likely results, however.

Table 1 also confirms the following results:

a) Early retirement causes a significant reduction in the level of retirement income due to the shorter accumulation period and the extended period of retirement. A retirement age of 60 causes a 32.7 percent reduction for males and a 31.4 percent reduction for females. These significant reductions in the level of retirement income need to be appreciated, particularly with recent world-wide trends toward earlier retirement.

b) Later entry into the work force, as is occurring with higher levels of youth unemployment and increasing years of education, also results in a lower level of retirement income due to the shorter period of accumulation. This reduction can be offset if the increased period of education raises the level of lifetime earnings.

c) These two trends, of later entry and earlier retirement, can have a devastating effect on the ultimate level of benefit. For instance, the expected retirement income with an entry age of 25 and a retirement age of 60 is 54 percent for males and 55 percent for females of the income received by a person who enters at age 20 and retires at age 65.

d) Changes in the investment strategy have the expected result with higher variability if the risk (as measured by the standard deviation) is increased and a reduced mean and variability if more conservative investment options are chosen. If Strategy C is chosen, the mean retirement income is reduced 59 percent while the standard deviation is reduced 88 percent.

e) If the standard deviation for Strategy A is reduced (which may occur within a prolonged low inflation environment and/or with greater smoothing of the investment returns), the expected value is almost unchanged, whereas the standard deviation and the range between the 5th and 95th percentiles are both reduced 25 percent.

f) Female life expectancy is considerably higher than males. Based on the Australian Life Tables 1985-1987, a 65 year old female is expected to live 18.56 years (or 27.1 percent longer than a male). When the retirement benefit is expressed in terms of a lifetime annuity, females receive a smaller level of income for the same level of contributions. Using the base assumptions, the expected level of income for a 65 year old female retiree is 20.0 percent below her male counterparts. (Within the Australian context, gender-based annuity rates are permitted.)

g) The previous discussion relates only to full-time workers. As expected, those who experience some periods of part-time work or who temporarily leave the work force have reduced retirement incomes. For instance, working in a part-time capacity for ten years from age 30 reduces the expected retirement income 15.5 percent for both males and females. Naturally, larger reductions in the expected retirement income occur if the person spends more time out of the work force.

h) Changes to the assumed mean of the inflation level do not cause a significant change to the results, as the investment returns and salary increases are adjusted automatically. As expected, an increase in the standard deviation of the inflation distribution leads to an increased variability in the level of retirement income.

i) Table 2 highlights the impact of a 15 percent tax on contributions and a 7.5 percent tax on investment income. The expected level of benefits is reduced 27.8 percent for both males and females under the base conditions. Even if there is a reduction in the taxation of the retirement income (as occurs in Australia, with a 15 percent tax rebate on pensions), it is likely that the introduction of taxation during the preretirement period (which has been considered in other countries) will result in a reduction in the actual level of retirement income received by the retiree.

j) The annuity rates offered at retirement to convert the accumulated benefit to a lifetime annuity can have a significant impact on the ultimate level of retirement income. If the underlying interest rate used to determine the indexed annuity rate increases from 1 percent above the inflation figure in the year preceding retirement to 2 percent above this inflation rate, the expected level of the annuity increases 6.9 percent.

This last result is important for members of defined contribution plans, as the actual level of any lifetime annuity will depend on the annuity rates available at the date of conversion. This represents a one-off conversion. The annuity rate used becomes critical in determining the actual level of retirement income received if the lump sum benefit is to be converted into an annuity stream at the date of retirement. In reality, such a system represents a random event, within certain bounds, where the level of retirement income can vary significantly due to the actual date of retirement even when all other factors are identical. Most members of defined contribution plans are not aware of this annuity rate risk that they bear whenever their retirement benefit is not expressed as a defined pension in terms of final (or final average) salary and they are required to convert their accumulated benefit into an income form. One approach to overcome this problem is to provide retirees with a fixed period (say, five years) during which they must convert their benefit into an annuity. Such an approach removes the one-off option while maintaining the requirement to convert their accumulation into an income stream.

The above results highlight the risks associated with variable investment returns and the provision of retirement benefits through a defined contribution approach. These risks cannot be removed without adopting a conservative investment strategy. Naturally, such a deci-

sion will result in lower benefits or higher long-term contribution rates. Neither of these results are optimal. An important but often forgotten question that needs to be addressed on a regular basis is: Who should bear the investment risk associated with the accumulation of contributions over the long term for the provision of retirement income? Should it be the employer, the individual, the government, or a combination of these parties?

This question has been answered in a variety of ways over time and in different countries. In some instances, the government (and hence the taxpayers) has removed the investment risk with the development of a generous social security system. This approach introduces other risks, including demographic and political risk. Elsewhere, defined pension schemes are common and the sponsoring employer has accepted the investment risk during the preretirement period. Even in these instances, certain risks remain. The trend toward defined contribution plans means that a higher proportion of the risks associated with the provision of retirement income is being accepted by the individual member. It may be claimed that with greater individual responsibility and a relative decline in the importance of the welfare state, this represents an appropriate response. It is also important, however, that individuals are aware of the consequences of the investment risk associated with defined contribution plans.

4 Summary and Conclusions

In recent years, there has been a shift from defined pension schemes to defined contribution schemes in several countries for a variety of reasons. This trend has placed a greater level of responsibility for retirement income on the individual member. Within this changed environment, individual members need to ask questions such as:

a) What is an appropriate level of contribution to provide security in retirement?
b) What are the major risks involved and who bears them?

The results in this paper, based on a simulation model using stochastic estimates for investment returns and the level of inflation, assist in preparing a response to these questions.

The results in Tables 1 and 2 suggest that a total superannuation contribution rate of 9 percent to 10 percent of salary (assuming no taxation in the preretirement period) or 12 percent of salary (with taxa-

tion at the Australian levels) provides, on average, a reasonable retirement income in terms of final salary for a single male, assuming that the contributions have been paid for at least 40 years. It is important to stress that these figures ignore any social security benefits. Therefore, the contribution levels should be reduced where a social security pension also is received. The results also represent average results; it is likely that at some time in the future, a particular cohort of retirees who have saved for 40 or 45 years will receive an inadequate retirement income due to the variability of the investment returns during the preretirement period.

Even if we concentrate on the average result (which does not represent the total story), a 9 percent to 10 percent contribution rate (assuming the tax exempt scenario) is not sufficient for many individuals. Some of the circumstances where a higher contribution rate is needed include:

a) Females who have longer life expectancies.
b) Members with dependent spouses.
c) Individuals who choose or are forced to take early retirement;
d) Individuals who enter the work force later due to early periods of unemployment or increased education.
e) Individuals who do not work full time throughout their career.

In many cases, an individual may be subject to a number of these factors (e.g., a female with some part-time work experience who retires at age 60) which would result in the need for a high contribution rate if a reasonable retirement income benefit is to be provided.

When one considers the small proportion of the work force who will be employed full time for 40 or 45 years and the variability in the investment returns over the long term, it is reasonable to conclude that a contribution rate equal to 9 percent of earnings will not provide an adequate level of retirement income for most retirees. This conclusion is strengthened by the fact that the above figures exclude any allowance for expenses.

Due to the enormous variety of individual circumstances, it is impossible to select a long-term contribution rate that will be satisfactory to everyone. In view of the current results, a total contribution rate for retirement income in the order of 12 percent of earnings (in a tax exempt environment) may be a reasonable long-term objective for many individuals. A higher contribution rate would be required if the fund were subject to taxation during the preretirement accumulation period.

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